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Diurnal time budget of breeding Black-necked Crane (*Grus nigricollis*) in Changthang, Ladakh, India

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Abstract: The time budget studies are an appropriate tool in understanding patterns of habitat utilization, exploitation of resources, and factors that limit survival. All this once understood can be integrated in developing of management strategies. Diurnal time budget of the Black-necked Crane (*Grus nigricollis*) was studied in Ladakh during breeding seasons in 2008, 2009 and 2010. In order to understand the activity patterns during various stages of breeding cycle, the entire breeding period of a particular year was divided into three phases: pre-breeding, breeding and post breeding. Between 2008 and 2010, a total 95 days were spent in the field and Black-necked Cranes were observed for 785 hours. All observations were made during the day time only between dawn and dusk (6:00 to 19:00). During the observation period, 16,314 behavioural events were recorded. Feeding behaviour was most prevalent accounting for 48.5 ± 1.3% (mean ± *SE*) of the crane's diurnal time budget. It was followed by resting (14.2 ± 1.2%), locomotion (10 ± 0.7%), breeding activities (10 ± 2.6%), maintenance (5.7 ± 0.5%), out of sight (5.4 ± 1.9%), and alert (4.1 ± 0.9%). Black-necked Cranes spent 1.5 ± 0.3% of its time in defense while at least 0.7 ± 0.2% in courtship activities. In the present paper percentage breakdown of overall diurnal activity of the Black-necked Crane have been provided. While studying the activity in various habitats, it was found that Black-necked Cranes spent maximum (43 ± 0.9%) time in marsh meadows as compared to other habitats.

Keywords: Ladakh; Changthang; Black-necked Crane; Time budget; Breeding season

印度拉达克羌塘地区黑颈鹤日间行为时间分配

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摘要：时间分配研究是理解栖息地利用模式、资源利用和限制物种生存因素的合适手段，这些一旦掌握清楚了便可被整合到管理策略的制定中。于 2008 年、2009 年和 2010 年繁殖期对拉达克地区的黑颈鹤 (*Grus nigricollis*)日间行为时间分配进行了研究。为了更好地统一繁殖周期内不同繁殖阶段的活动模式，将黑颈鹤的繁殖期分成繁殖前期、繁殖中期和繁殖后期。调查期间，共进行了 95 天野外调查，黑颈鹤观察时长达 785 h，所有观察在 06:00—19:00 完成，共记录到 16 314

次行为事件。该文中黑颈鹤的日间行为时间分配以不同行为的百分比来表示。繁殖期内，黑颈鹤的取食行为占（48.5 ± 1.3）%，其次分别为休息 [(14.2 ± 1.2)%]、运动[(10 ± 0.7)%]、繁殖[(10 ± 2.6)%]、保养[(5.7 ± 0.5)%]、警戒[(4.1 ± 0.9)%]、保卫[(1.5 ± 0.3)%]和求偶炫耀[(0.7 ± 0.2)%]，另有 (5.4 ± 1.9)%]的时间黑颈鹤飞出观察视野。相较于其他生境，黑颈鹤在沼泽草甸生境中停留的时间最长[(43 ± 0.9)%]。

关键词：拉达克；羌塘；黑颈鹤；时间分配；繁殖期

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In order to survive and reproduce, a species must effectively perform a variety of activities, each requiring an expenditure of time (Verner, 1965). By recording the time spent on each activity, one can construct a time budget which can conveniently be linked to the energy budget. Each activity performed by an individual either requires energy (energy expenditure) or directed to gain energy. Thus the measures of time and energy by free living animals can provide quantitative tests of a number of ecological theories, regarding such diverse phenomenon as foraging strategies, resource competition or parental investment (Goldstein, 1988) on one hand, and can be helpful in understanding evolutionary implications such as survival, population regulation and reproductive success on the other hand.

Small variation in time budgeting can affect reproductive success (Orians, 1961). For instance, increase in feeding-related activities (e.g., caused by a decrease in food availability) is likely to be at the expense of parental vigilance. Conversely, increase in vigilance (e.g.,due to increased disturbance) may have a negative impact on feeding related activities. An increase at any one side can potentially negatively affect reproductive success in many species of cranes (Brater et al,2007). The amount of time and energy which a bird devotes to different activities must inevitably influence its survival (Orians, 1961). Considering the above, we made efforts to study activity time budget of Black-necked Crane during breeding season so as to understand variations in the day light activity budget. The present study is expected to provide better understanding of resource utilization and energy expenditure by the breeding crane population, which in turn will help strengthen long-term conservation and management strategy for the species.

METHODS

Black-necked Cranes in Changthang (N32º25′ – 34º35′ and E77º30′ – 79º29′), Ladakh breed at various locations. However, considering the accessibility to the area and availability of logistic support, breeding pairs at Tsokar (N 33°15'21.96", E78° 3'7.20"), Hanle (N 32°47'18.56", E78°59'32.23"), Yaya Tso (N33°19'21.59", E78°28'46.97") and Lungparma (N33°47'55.91", E78°22'29.43") were selected to collect intensive field data on activity time budget. Cranes arrive in the study area during the first week of April and leave by the first week of November. We divided the total breeding period of cranes in Changthang into the following three stages.

Pre-breeding stage: Upon arrival cranes begin strengthening their pair bonds, perform courtship displays, copulate during April and first week of May, and side by side build their nests.

Breeding stage: During the rest of May until the first week of July, cranes lay eggs, incubate them and hatchlings are out of their nests.

Post-breeding: From the time when the hatchlings are out of their nests until their departure to wintering grounds in the last week of October or, in some cases, the first week of November.

Data collection

Vast open environment in Ladakh where Black-necked Cranes build their nests makes it easier to locate them but difficult to observe behavioural acts from close quarters. In the absence of cover, it is also easier for cranes to get disturbed by the presence of observers. During recent several years while conducting status surveys it was observed that cranes take notice of human presence if someone approaches them closer than 500 m. Cranes can be observed from a distance of about 500 m through monocular telescope but it was quite tiring to continuously focus on them for long hours. It was decided to develop ways to approach the cranes closer so that observations can be made through field binoculars with relative ease. Two types of hideouts (blinds) were designed; a permanent hideout which was fixed at a suitable place and another light-weight portable blind

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which was used when it was difficult to record cranes' activities from the permanent hideout. The permanent hideout was placed at a vantage point close to the nesting site in such a way that it blended into the background and the area of crane activities was in perfect view. The portable blind was made of light weight strong steel frame of 2.5 ft width, 2.5 ft length and 7 ft in height that was covered with light cream colour upholstery that matched the background. There were peep windows at all four sides of the blind at eye level so that when observer is in, the blind is closed from all sides and observations can be made from the peep windows. The portable blind proved to be a useful tool in observing cranes from close quarters, especially during the post breeding period.

Since Black-necked Cranes are known for site fidelity, the hideouts were placed at about 400 to 500 m from the previous year's nesting site, a few days prior to the expected arrival of Black-necked Cranes in the area, so that they get accustomed to the presence of the blind. In all cases crane pairs built their nests at the previous year's nesting sites. Observations were started after three to four days of crane's arrival. On the first day of our observations, an observer entered the portable blind and started moving with it very slowly for ~50 meters, continuously watching the reaction of cranes through the peep windows. Our presence remained unnoticed as the birds were not disturbed and were busy performing their activities. In subsequent days, we moved again ending up as close to cranes as in ~200 m, and could easily observe behavioural acts through a pair of Nikon field binoculars.

We employed focal animal sampling method (Martin & Batesan, 1986) to collect data on behavioural acts every 5 minutes. We recorded activity only during the sampling, irrespectively to what the crane was doing earlier or later. Activities of male and female cranes were recorded separately. In the absence of sexual dimorphism, it was difficult to identify sexes; however, in breeding territories where only one pair is present and both cranes remain within the breeding territory, identification of male and female initially was easier on the basis of unison calls and later on the basis of the size of the crane. Normally, female is slightly smaller than the male; however, the distinction in size can only be possible when both male and female are together. A male bird with a green tag on its right wing at Hanle further helped to collect specific data. Behavioural acts were classified into the following nine categories.

Feeding: Probing and searching for food, pecking, nibbling, capturing food item, swallowing, and drinking.

Alert: Walking/standing with the head stretched upward, looking around, detecting threats.

Resting: Standing on one leg or both legs with the head tucked backward, lying with droop head, lying and not incubating.

Locomotion: Walking, running, and leaping.

Defense: Chasing intruding cranes, chasing other approaching animals, responding to any perceived threat through calls and /or vigorous head shaking.

Courtship: Courtship displays.

Breeding: Mating, egg laying, incubating, nest guarding, nest repairing, and rotating eggs.

Maintenance: Preening, stretching, shaking head, bathing, flattering.

Out of sight: When crane flew out of the area and not seen.

All observations were made during the day time only between dawn and dusk. In Changthang, sun light appears between 5:30 and 6:00 AM and sun sets around 19:00 PM local time. In order to collect hourly behavioural data, we divided the day time into 13 hour-long session between 6:00 and 19:00.

Data analysis

Frequencies of occurrence of each behavioural act were pooled hourly and daily from the five minutes behaviour samples to analyse time-budget and diurnal behavioural rhythm. Data were first expressed as percentage of frequency of each behavioural act. Mean frequencies of behavioural acts were calculated with standard error and compared using One way ANOVA, Kruskal Wallis and Mann Whitney *U* statistical tests as per the requirements of the data. All calculations were carried out using SPSS version 14.1.

RESULTS

The following results are based on the field data collected pertaining to time budget activity of Black-necked Cranes around four wetland sites viz. Tsokar, Hanle, Yaya Tso and Lungparma. Between 2008 and 2010, each year's breeding season from April to October, a total 95 days were spent in the field and Black-necked Cranes were observed for 785 hours. During the observation period, 16,314 behavioural events were recorded.

Overall activity pattern of the Black-necked Crane

During the study period, feeding behaviour was most prevalent accounting for 48.5 ± 1.3% (mean ± *SE*) of the crane's diurnal time budget. It was followed by resting (14.2 ± 1.2%), locomotion (10 ± 0.7%), breeding activities (10 ± 2.6%), maintenance (5.7 ± 0.5%), out of sight (5.4 ± 1.9%) and alert (4.1 ± 0.9%). A Black-necked Crane spent 1.5 ± 0.3% of its time in defense while at least 0.7 ± 0.2% in courtship activities. Figure 2 provides details of percentage breakdown of overall diurnal activity of Black-necked Crane.

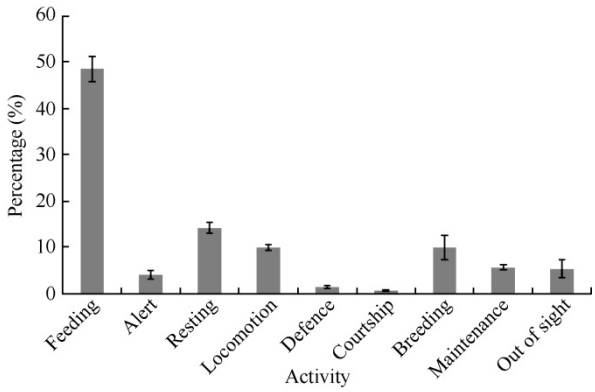

Figure 2 Overall % (mean ± *SE*) of various activities of Black-necked Cranes in Changthang, Ladakh

Analysis of the data revealed that there were variations in mean frequencies among different types of activities. Mean frequency (mean ± *SE*) of feeding was the highest occurring 83.2 ± 4.8 times per day. It was followed by resting (24.4 ± 2.0), locomotion (17.2 ± 1.2), breeding (17.1 ± 4.5), maintenance (8.8 ± 0.9), out of sight (9.2 ± 3.3) and much lower frequencies were recorded for other categories of activities (Table 1).

Table 1 Frequency, mean frequency per day and standard error of mean (*SE*) of various activities of Black-necked Cranes in Changthang

Types of activity	Frequency	Mean freq/day	*SE*
Feeding	7907	83.2	4.8
Alert	671	7.1	1.5
Resting	2319	24.4	2.0
Locomotion	1633	17.2	1.2
Defense	242	2.5	0.5
Courtship	107	1.1	0.3
Breeding	1625	17.1	4.5
Maintenance	932	9.8	0.9
Out of sight	878	9.2	3.3

Kruskal Wallis statistics showed that there were significant differences among the mean frequencies of various types of activities (KW χ^2= 66.3, *df* = 8, *P*< 0.01).

Overall sexual variation in activity pattern of Black-necked Cranes

Activities of male and female were recorded separately. The overall diurnal activity patterns of male and female were somewhat similar. For instance, males spent about 4.0 ± 0.9% of their time budget on alert behavior, while females spent 3.4 ± 0.7%. Similarly, on resting males spent 12.9 ± 1.1%, while female spent 13.0 ± 1.1%; on locomotion males spent 8.6 ± 0.6% and females spent 9.7 ± 0.7% of their diurnal time budget. On feeding males spent less time (39.5 ± 2.2%) as compared to females (49.6 ± 3.0%), while males remained more out of sight (21.4 ± 2.8%) as compared to females (5.1 ± 2.1%).

Mean frequencies per day of different activities of males and females differed; however, the differences were not statistically significant except in case of "out of sight" where males remained absent more frequently than the females from their breeding territories and the difference was statistically significant (Mann Whitney *U* = 2430, *P*< 0.01).

Overall activity pattern of Black-necked Cranes during different stages of breeding

Cranes spent more time of its diurnal budget on feeding during pre-breeding stage (53.4 ± 4.6%) as compared to breeding (41.2 ± 3.7%) and post-breeding (51.7 ± 4.3%) stages. Similarly, higher percentages of time were spent on alert (5.9 ± 2.2%) and resting (17.6 ± 2.2 %) during pre-breeding stage as compared to breeding stage (3.5 ± 0.9 and 13.9 ± 1.6%, respectively) and post-breeding stages (3.0 ± 1.6 and 15.7 ± 1.3%, respectively). On locomotion, cranes spent more time during post-breeding stage (13.8 ± 1.5%) as compared to pre-breeding (10.6 ± 1.2%) and breeding (8.1 ± 0.9%) stages. Comparatively, more time was spent on defense during pre-breeding stage (1.7 ± 0.7%) than in breeding and post-breeding stages (1.5 ± 0.3 and 0.5 ± 0.2% respectively). Since courtship occurs during April and May and hence during pre-breeding stage, it tookobviously more time (1.4 ± 0.7 % of diurnal time budget) as compared to breeding stage (0.5 ± 0.1% of diurnal time budget). On maintenance, crane spent 8.0 ± 1.1% of its diurnal time budget during pre-breeding stage and about half (4.5 ± 0.6%) each during breeding and

post-breeding stages (Figure 3). Maximum time of cranes' diurnal budget was spent on "out of sight" during the breeding stage (10.1 ± 3.7%) as compared to pre and post breeding stages (Figure 3).

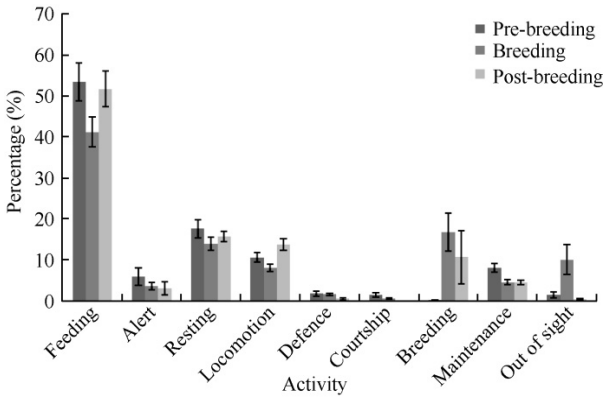

Figure 3 Mean frequencies (%) of various activities of Black-necked Cranes during different stages of breeding season at Changthang

Mean frequencies per day of feeding differed significantly between pre-breeding, breeding and post-breeding stages (KW χ^2 = 12.9, *df*= 2, *P*<0.01)**.** There were significant differences in mean frequencies per day of alert (KW χ^2 = 09.0, *df* = 2, *P*<0.05), resting (KW χ^2 = 06.2, *df* = 2, *P*<0.05), defense (KW χ^2 = 07.8, *df* = 2, *P*<0.05), and maintenance (KW χ^2 = 21.9, *df* = 2, *P*<0.01) during the three breeding stages. Differences in mean frequencies of locomotion were not statistically significant during different breeding stages. Courtship and breeding occurred only during two stages. There were no significant differences in the mean frequencies of courtship during pre-breeding and breeding stages (Mann Whitney *U* = 339.0, *P*> 0.05), while breeding activity was significantly different between breeding and post-breeding stages (Mann Whitney *U* = 335.5, *P*< 0.05). Mean frequencies per day of various activities are given in Table 2.

Activity pattern of Black-necked Cranes in different habitat types

In performing different activities, Black-necked Cranes spent maximum (43 ± 0.9%) time in marsh meadows as compared to other habitats: herbaceous meadows (22.7 ± 0.4%), desert steppe (18.4 ± 3.9%), water (13.0 ± 0.7%), and barren land (2.9 ± 0.2%). Figure 4 provides a breakdown of time (%) spent by cranes in different habitat types. Analysis of these data revealed significant differences in utilization of various habitats while performing daily activities (KW χ^2 = 98.0, *df* = 4, *P*< 0.01). Table 3 provides details of mean frequencies per day of activities in different habitats.

Analysis of data on feeding and resting revealed that crane spent maximum time feeding in marsh meadows (61.3 ± 3.6%) followed by water (17.2 ± 3.7%) and herbaceous meadows (10.9 ± 2.0%). Occasionally, cranes were observed feeding in dessert steppe and barren land and the percentage of time spent in these habitats were 5.9 ± 2.3 and 5.4 ± 4.7% respectively.

Black-necked Crane spent most of its time, resting in marsh meadows (55.1 ± 5.1 %) and it was followed by water (20.2 ± 5.6 %) and herbaceous meadows (19.6 ± 3.9%). Cranes spent very little time resting on barren land and it was only 5.2 ± 0.9% of their time budget on resting. They were never observed resting in dessert steppe.

Table 2 Mean frequencies per day (mean ± *SE*) of various activities of Black-necked Cranes in different stages of breeding season at Changthang

Activity	Pre-breeding	Breeding	Post-breeding	Test statistics	*P*
	Mean ± *SE*	Mean ± *SE*	Mean ± *SE*		
Feeding	107.1 ± 9.3	79.2 ± 7.1	61.2 ± 5.1	χ^2=12.9	<0.01
Alert	11.9 ± 4.3	6.8 ± 1.8	3.5 ± 1.9	χ^2=09.0	<0.05
Resting	35.2 ± 4.4	26.7 ± 3.1	18.6 ± 1.5	χ^2=06.2	<0.05
Locomotion	21.2 ± 2.3	15.5 ± 1.7	16.3 ± 1.7	χ^2=04.4	>0.05
Defense	3.4 ± 1.3	3.0 ± 0.6	0.6 ± 0.3	χ^2=07.8	<0.05
Courtship	2.8 0.9	1.0 ± 0.2	0.0	*U*=369	>0.05
Breeding	0.0	32.0 ± 8.9	12.6 ± 7.7	*U*=335	<0.05
Maintenance	16.0 ± 2.1	8.7 ± 1.2	5.3 ± 0.6	χ^2=21.9	<0.01
Out of sight	2.9 ± 1.5	19.4 ± 7.1	0.4 ± 0.3	x^2=02.6	>0.05

Test statistics χ^2 = Values of Kruskall-Wallis Chi Square; *U* = Mann Whitney *U* test Z scores

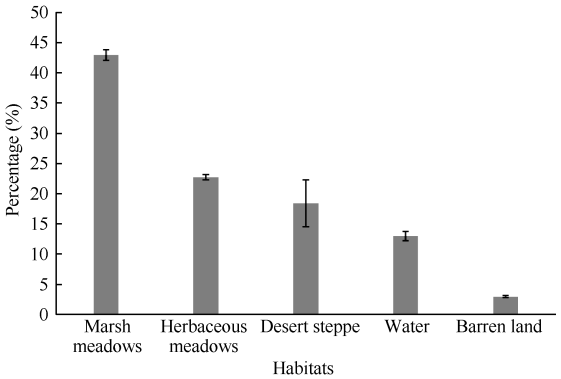

Figure 4 Mean percentages of time spent by cranes in different habitat types

Table 3 Frequency, mean frequency per day and *SE* of mean of overall activity of Black-necked Cranes in different habitat types

Types of activity	Frequency	Mean freq/day	*SE*
Marsh meadows	10893	18.2	0.9
Herbaceous meadows	3450	9.6	0.4
Desert steppe	1035	7.8	3.9
Water	298	5.5	0.7
Barren land	638	1.2	0.2

Activity rhythm of Black-necked Crane

Feeding activity did not show any obvious rhythm with time. Faint peaks were noticeable at 9:00 and 15:00. However, the mean frequencies of feeding during different hours of the day differed significantly ($F_{12,689}$=1.99, P< 0.05).

Alert behavior peaked early in the morning, about mid day (13:00) and in the evening after 17:00 but the differences in the mean frequencies in different hours of the day were not statistically significant ($F_{12,168}$=1.27, P> 0.05).

Resting behavior showed a sharp decline in the evening after 16:00 with heightening of activity at about mid day. Mean frequencies of resting during different hours differed significantly ($F_{12,498}$=2.01, P< 0.05).

Locomotion showed no marked differences during different hours of the day except a trough between 11:00 and 13:00 with its downwards peak at noon. There were no significant differences in the mean frequencies of locomotion between different hours ($F_{12,449}$ = 1.06, P> 0.05).

There was an obvious rhythm in defense behavior with a peak in the morning and a sharp decline afterwards till mid day. It again peaked slightly at 16:00. There were significant differences in the mean frequencies of defense during different hours ($F_{12,120}$ =2.699, P< 0.05).

Courtship behavior remained more or less consistent from early morning till about mid day and declined to its lowest at 12:00 and peaked at 16:00. However, the differences in mean hourly frequencies were not statistically significant ($F_{12,259}$=1.27, P> 0.05).

Breeding behavior peaked early morning with a sharp decline at 07:00 and remained more or less consistent till 15:00 and again peaked at 18:00. There were no significant differences in the mean frequencies between different hours of the day ($F_{12,\ 828}$=0.59, P> 0.05).

Maintenance behavior peaked just after waking up and declined sharply with a trough between 10:00 and 12:00. There was a slight peak at 12:00, afterwhich the activity got reduced till the end of the day. Mean frequencies of maintenance did not vary significantly between different hours of the day ($F_{12,1324}$ = 0.97, P> 0.05).

There were no marked differences in out of sight behavior of Black-necked Cranes during different hours of the day. It remained comparatively more out of sight between 06:00 and 18:00 but the differences were not significant ($F_{12,424}$= 0.66, P> 0.05).

DISCUSSION

The strategy of any organism is to accumulate sufficient energy to survive. Furthermore, the migratory species are required to store excessive energy in order to meet migration costs and unexpected circumstances during migration, such as sudden temperature drops and other environmental stresses. Also during the breeding season, male birds have to establish a territory to attract a mate, while females seek and find a mate. These activities require additional energy demand that can only be fulfilled by excessive energy. Evolutionary wisdom suggests that selection favours those individuals that perform these activities on the available excessive energy. The Black-necked Crane as a migratory species is also expected to devote more time on feeding in order to maximize energy gain both during and after the breeding seasons. Cranes at Changthang arrive and breed during a short summer. The excessive energy accumulated at their wintering grounds helps them to carry on during the breeding season while the energy accumulated at the breeding grounds facilitates the return migration to their

wintering areas. During the present study, cranes spent maximum of their time (about 50%) on feeding, which was similar to the study conducted in Ruoergai Wetland National Natural Reserve, where Black-necked Cranes spent about 45%of their diurnal time budget on feeding (Yang et al, 2007). Other species of cranes also reported to exhibit similar patterns where feeding is one of the most frequent diurnal activity. For instance, the Hooded Crane (*Grus monacha*) at Shengjin lake spent about 60% time of its diurnal budget on feeding (Zhou et al, 2010). Feeding is a predominant activity of the Siberian Crane (*Grus leucogeanus*) in Zhalong Wetland (Feng et al, 2007) and of the Eurasian Crane (*Grus grus*) in Dehesas (Aviles, 2003). Not only cranes but other aquatic bird species, like the Red-crested Pochard and the Mute Swan, also exhibit similar trends where feeding is the most frequent activity compared to other behavioral acts (Dopfner, 2009).

Food availability has been shown as one of the main factors influencing time budget of several bird species (Carco, 1979; Hixon et al, 1983; Hunter et al, 1984; Davies & Lundberg, 1985; Michot et al, 2006; Yang et al, 2007). Lee et al (2007) argued that cranes spend more time foraging in areas where food resources are abundant than in areas where food resources are limited and therefore Hooded Cranes in wetland on Chongming Island spend more time on foraging (Jing et al, 2002). However, this argument is not in conformity with the optimal foraging theory, as any species would acquire more energy spending less time in an area of high food abundance, where search time is low, as compared to areas of low food abundance where search time is higher.

Alert behavior can be related to the level of threat a species perceives in its habitat. In Caohai Lake, China, Black-necked Cranes spend more time on alert behavior (Li & Ma, 1992) as compared to Rouergai Wetlands National Natural Reserve (RWNNR), where a crane spend 7% of its diurnal time budget on alert behavior (Yang et al, 2007). In Changthang, a crane also spent 7 % of its time budget on alert behavior, indicating low intensity of threat.

Studies of time budgets are especially useful for comparative studies such as between sexes, periods of the year, and habitats both within and across species (Holmes et al, 1979). There were significant variations in time budget of cranes during different breeding stages as has also been reported by Yang et al (2007). Cranes spent more time on feeding, resting, locomotion and maintenance during pre-breeding stage as compared to breeding and post breeding stages. During the breeding stage, cranes spent more time on breeding activities at the expense of maintenance, resting, and locomotion. During this stage feeding was comparatively reduced, mainly as the cranes have to allocate more time to incubation and other breeding-related activities. Feeding activity increases marginally once the breeding is over and chicks are out. This is a short period before return migration so probably cranes' strategy is to accumulate excessive energy.

Variations in activity pattern of male and female Black-necked Cranes probably have not yet been studied as we could not come across any published work on the aspect. The general activity pattern of male and female is more or less similar as far as feeding, resting, locomotion, defense and maintenance are concerned. Though in many species activity pattern of males and females differ, in Black-necked Cranes it is not so profound as both sexes share responsibilities of nest building, incubation and other breeding-related activities. The most striking difference between male and female activity is in the category of "out of sight" where males performed it several times more frequently as compared to females. As part of the strategy to optimize resource utilization, males leave the breeding territories more often so that females have enough food supply while feeding and taking care of chicks. In such circumstances, males probably take higher risk of exposing themselves to predators at the cost of ensuring regular food supply and better survival opportunities for their partners and progeny. Males spent twice the time females spent on alert behavior. Females compensate it by spending more time on breeding activities. Since defending against an intruder is a joint responsibility of male and female, both spend similar time on defense.

Time budget studies reveal how available habitats are used by a species (Frederick & Klaas, 1982), and also how well animals are able to exploit an area to meet their needs (Iverson, 1981). Cranes spent more than 65% of their time in marsh meadows and herbaceous meadows as compared to other habitats. It is largely due to the fact that these two habitats provide more food resources as compared to desert steppe and barren land. While feeding, cranes spend more time in marsh meadows as compare to any other habitat. Marsh meadows provide diverse food items such as tubers, fish and other aquatic invertebrates, while herbaceous meadows offer more

vegetarian food. During the breeding season many avian species feed more on animal food material in order to meet their increased protein demand, hence feeding more in marsh meadows is advantageous in order to harvest more energy by feeding both animal and plant food resources.

Cranes were never observed resting in a desert steppe. They spent more than 60% of their time resting in marsh meadows and over 15% in wáter, largely to stay safe from predators. Marsh meadows offer more cover and are more difficult for land predators to approach. Similarly, taking a rest in clear water, even though it exposes cranes to higher predation risk by enhanced visibility, may be safer since water acts as barrier for many land predators.

After the night sleep and rest, cranes start their activities by securing their territorial limits and defending it from any opportunistic intruder, and hence spend higher percentage of their time budget on defense and alert in comparison to other activities. Feeding activity remains low at the start of the day, progresses with time and remains more or less the same until the end of the day. Cranes spend more than 50% of their time budget on feeding, and the food resources are distributed more or less evenly. Therefore, it is more advantageous to feed throughout the day at a slow and regular pace and perform other activities intermittently (whenever required) rather than to concentrate on feeding alone at any particular period of the day. Moreover, if feeding is partitioned to a specific time block of the day than a bird has to feed non selectively.

Alert behavior peaks at about mid day and late evening, probably due to relatively higher human disturbance. Another peak in alert behavior during late evening may be related to the intrusion of nocturnal predators who start their activities at the dusk.

Resting peaks around mid day while there is an obvious trough in locomotion. Second peak in resting during mid day coincides with reduced breeding activities. The pattern of out of sight behavior was similar to that of feeding which strengthens the earlier view that cranes go out of their breeding territories in search of better food.

CONCLUSION

Most often time budget of a species is linked with energy budget as each activity performed by an individual requires either energy expenditure or energy gain. Thus assessing the use of time and energy by free living animals can be helpful in understanding of evolutionary implications such as survival, population regulation, and reproductive success. Feeding behavior was most prevalent accounting alone 48.5 ± 1.3 % (mean ± *SE*) of the crane's diurnal time budget. There were significant differences among the mean frequencies of various types of activities. The overall diurnal activity pattern of male and female was more or less similar. However, males spent comparatively less time on feeding and locomotion and more time on alert and out of sight as compared to females. During different stages of breeding, cranes spent more time on feeding, resting, defense, alert and maintenance during pre breeding stage as compared to breeding and post breeding stages. On locomotion, crane spent more time during post breeding stage. Black-necked Cranes spent maximum (43 ± 0.9%) time in marsh meadows as compared to other habitats; herbaceous meadows (22.7 ± 0.4%), desert steppe (18.4 ± 3.9%), water (13.0 ± 0.7%) and barren land (2.9 ± 0.2%). Maximum time spent on feeding and resting was recorded in marsh meadows as compared to other habitats (water, herbaceous meadows, desert steppe, and barren land). Activities such as feeding, locomotion, and out of site behavior did not show any obvious rhythm while other activities were differentially performed during different hours of the day and some of them, such as defense, courtship, breeding, and resting, showed obvious rhythms. Alert behavior can be related to the level of threat a species perceives in its habitat. At Changthang, a crane spent only about 7% of its time budget on alert behavior indicating low intensity of threat. Variations in activity pattern of male and female Black-necked Cranes were not as profound as in some other avian species due to the fact that both sexes share responsibilities of nest building, hatching and other breeding related activities. The most striking difference between male and female activity in the category of "out of sight" seems to be a part of the strategy to optimize resource utilization. Differential use of habitat is related to the availability of food resources and Black-necked Cranes spent more time in habitats where food resources are more abundant and diverse.

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